Wed Oct 1st 2014.

CIVL 498C Life Cycle Assessment

Week 5: Inventory Analysis

Presentation Outline

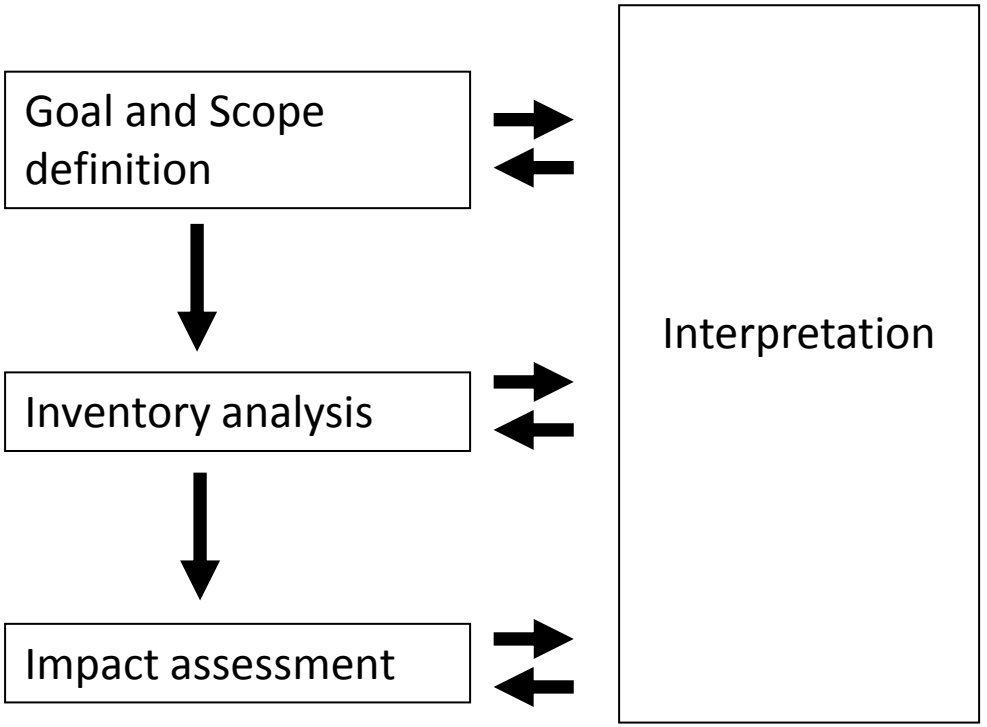
1. **What is Inventory Analysis?**
2. Life Cycle Inventory procedures.
3. Exercise developing and managing inventory data.

ISO LCA Methodological Framework

Defining and planning the study to be carried out on the system in question.

Measuring physical inputs and outputs from the system in question.

Assigning an environmental significance to inputs and outputs from the system in question.



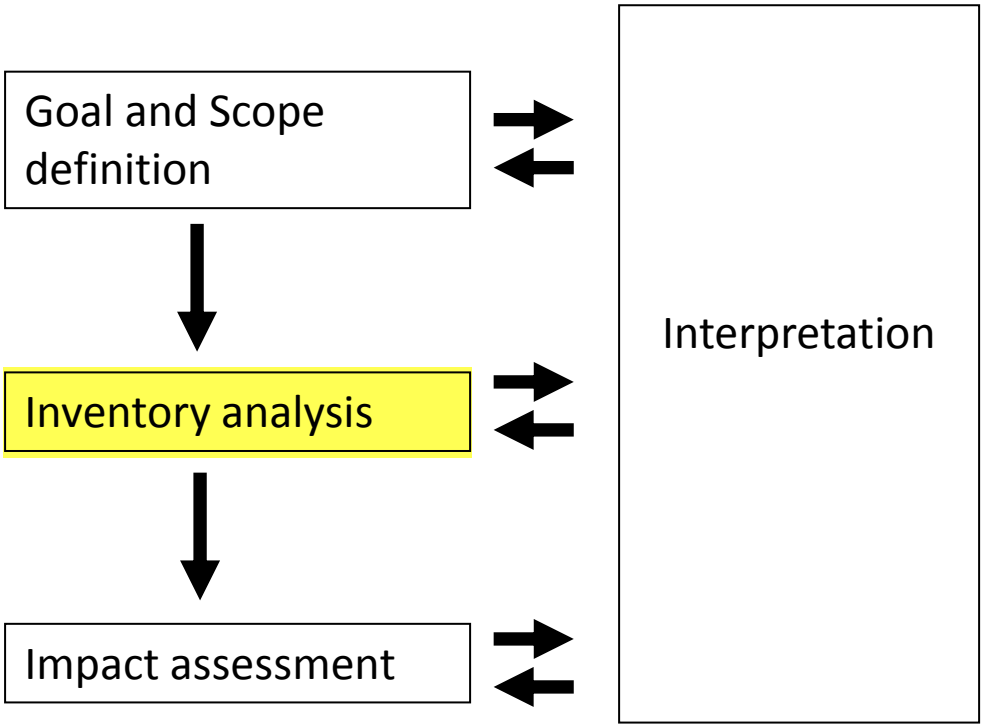
Was the study completed in accordance with international standards?

Is the study consistent to the defined system and study plan?

(ISO 14040:2006)

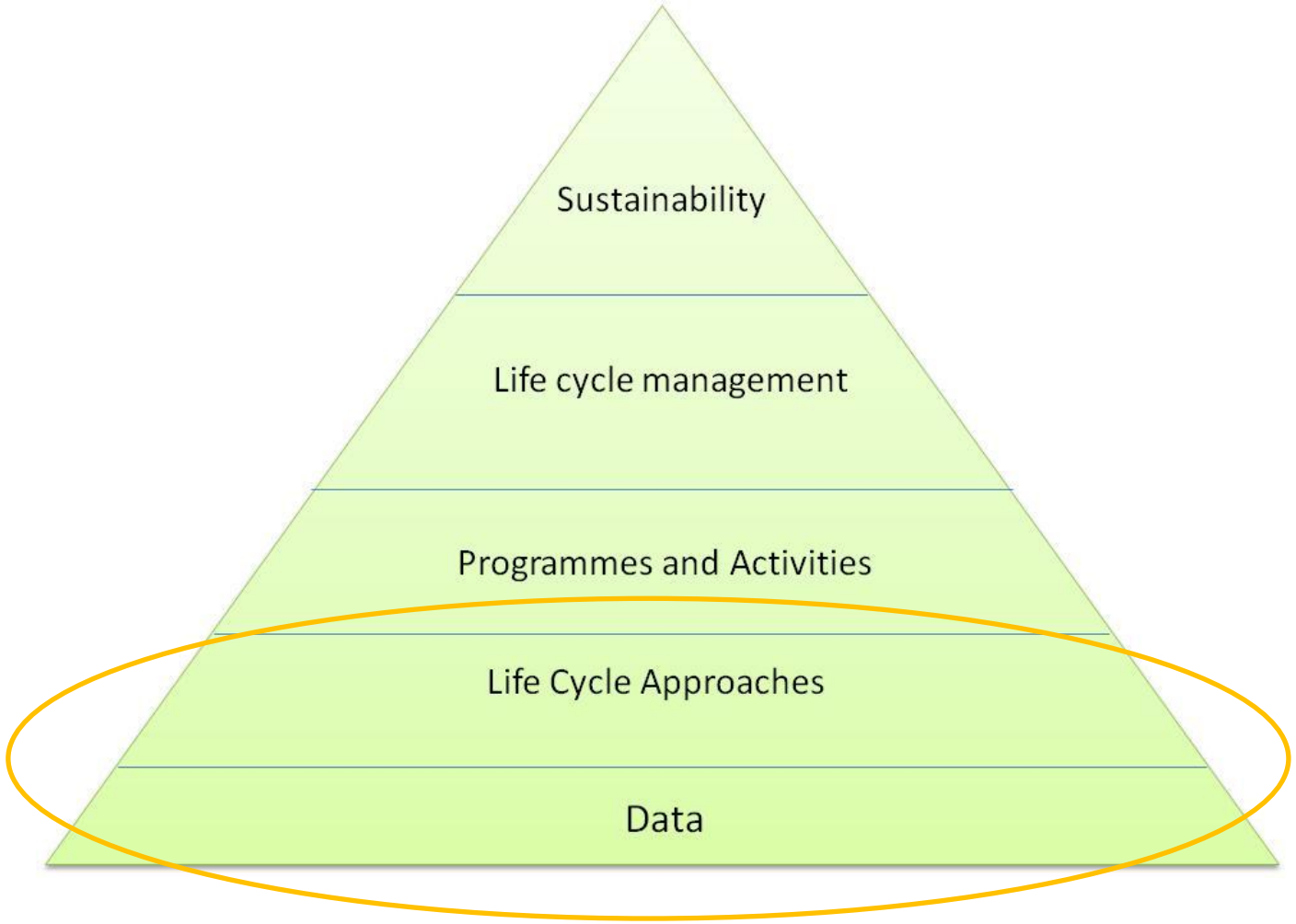
ISO LCA Methodological Framework

Measuring physical inputs and outputs from the system in question.



(ISO 14040:2006)

UNEP/SETAC Sustainability Framework



Life Cycle Approaches

Inventory Analysis

Impact Assessment

Resources

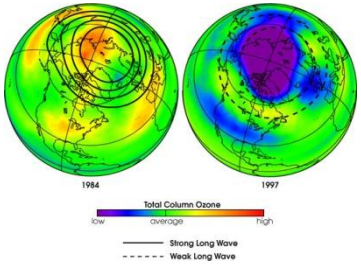
Energy

Air

Water

Land

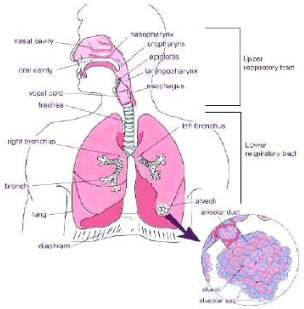
kg CO2 eq



kg CFC-11 eq

kg SO2 eq

kg O3 eq



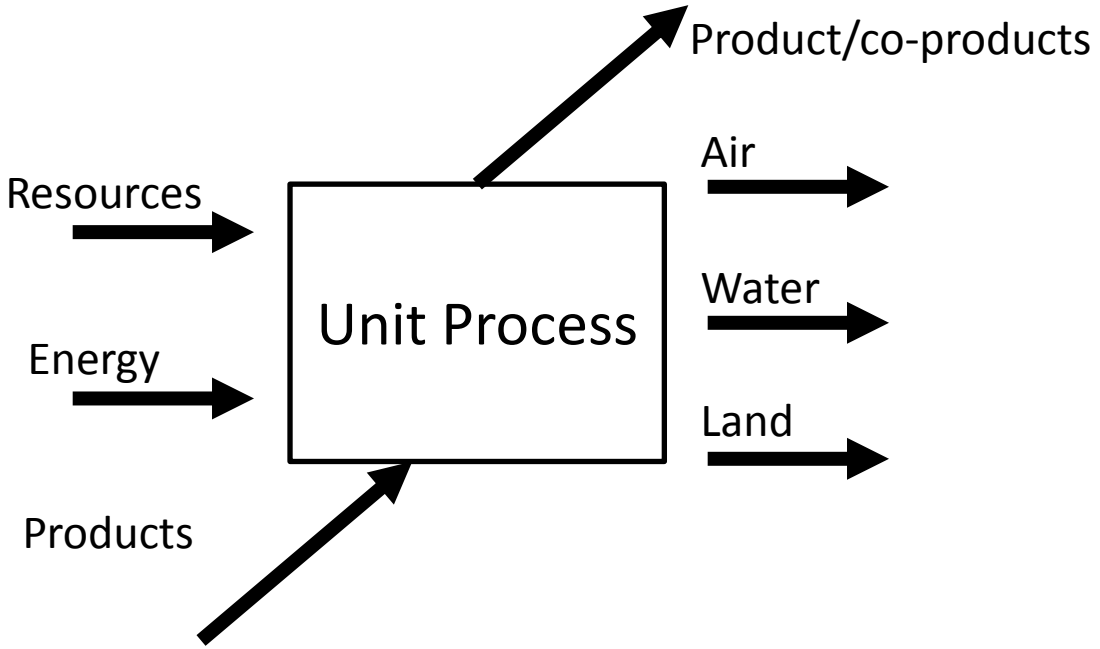
kg PM10 eq

kg N eq

Inventory Analysis Overview

Quantitative Data Collection

Measure amounts of all required ***flows*** crossing your System Boundary as per your G&S.



Qualitative Data Collection

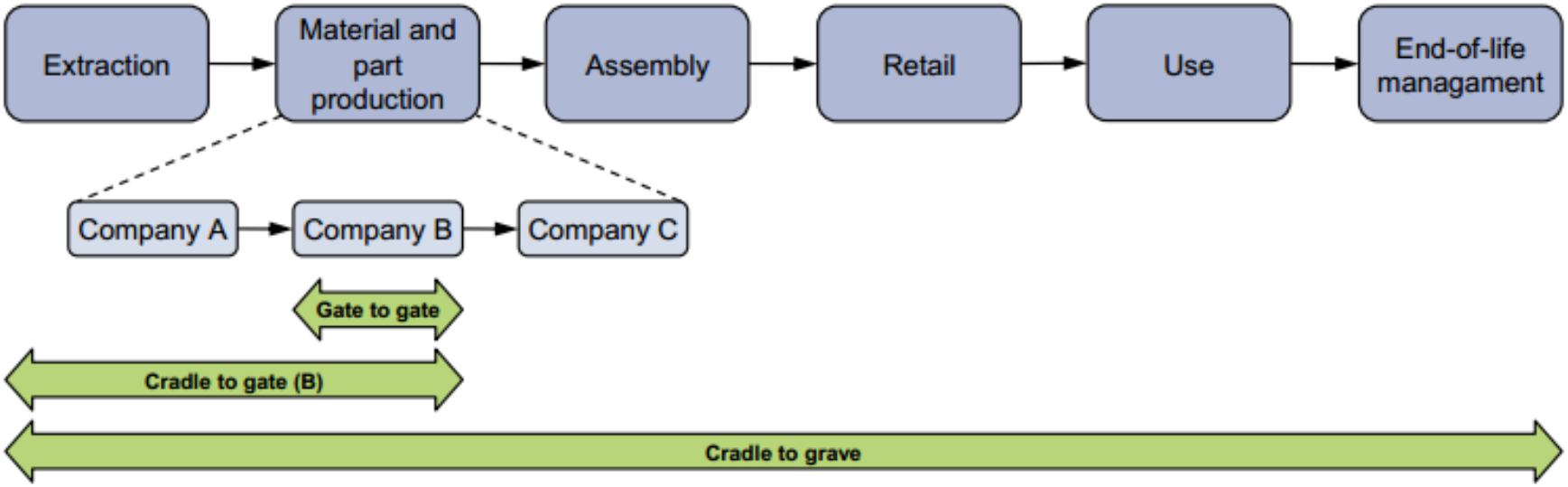
Describing
- ❑ age of data to be used
- ❑ technology of the process
- ❑ origin of raw materials
- ❑ locality of process
- ❑ impacted environments

Support your allocation
- ❑ prices
- ❑ physical relationships

Transportation
- ❑ distance
- ❑ routing
- ❑ type

Scope

- System boundary
  - Details the extent of the product system to be studied in terms of product components, life cycle stages, and unit processes.
  - Really need to reflect on what you're trying to achieve in this study (ie. reflect on your Goal) to ensure study is as complex as necessary but as simple as possible.
  - Draw a process flow diagram of unit processes
    - Focus on what is required to meet functional unit
    - How far upstream and downstream are you considering?



Presentation Outline

1. What is Inventory Analysis?
2. **Life Cycle Inventory procedures.**
3. Exercise developing and managing inventory data.

Method Overview

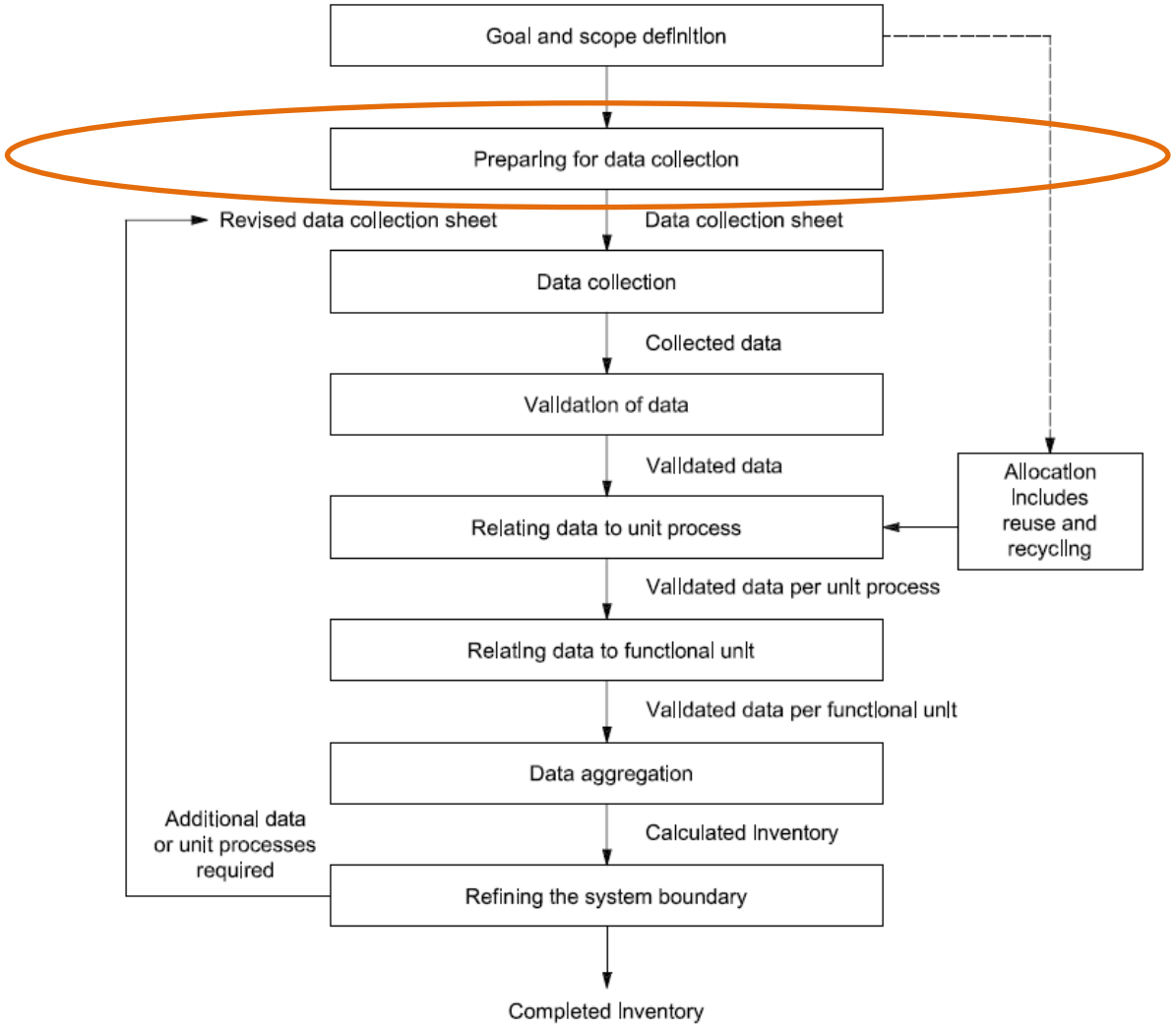


Figure 1 — Simplified procedures for inventory analysis

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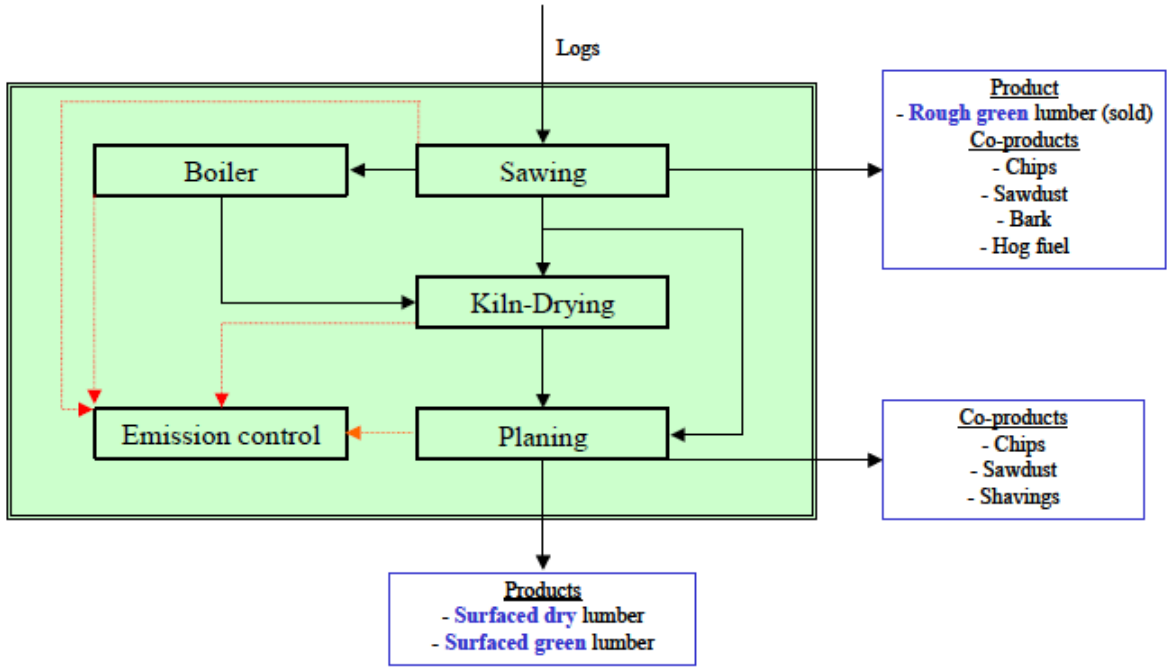
Preparing

Data Collection

- Build understanding of product system
  - Flow diagram
    - Show unit processes and input and output flows

Figure 3: Softwood Lumber Manufacturing Process



Preparing

Data Collection

- Build understanding of product system
  - Flow diagram
    - Show unit processes and input and output flows
  - Unit process description
    - Factors influencing inputs and outputs
    - Operating conditions
    - Units to be used for flows

Life Stage	Description
Kiln drying	Drying encompasses the kilns, loading area, and unloading/cooling (storage) and air drying areas.
Planing	Planing encompasses the unstacker, planer, and packaging areas. Each of these includes conveyance to the next unit process or plant gate.
Boiler	Boiler/co-generation equipment (energy generation) encompasses fuel storage, conveyance, boiler, turbines and steam distribution system.
Emission control	Emission control is devoted to air pollution control such as a multicyclone, dust collector, bag house and/or electrostatic precipitator.

Preparing

Data Collection

- Build understanding of product system
  - Flow diagram
    - Show unit processes and input and output flows
  - Unit process description
    - Factors influencing inputs and outputs
    - Operating conditions
    - Units to be used for flows
  - Data collection
    - Methods for measurement, calculation or estimation and treatment of missing data

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Preparing

Data Collection Tables

Completed by:	Date of completion:			
Unit process identification:	Reporting location:			
Time period: Year	Starting month:	Ending month:		
Description of unit process: (attach additional sheet if required)				
Material inputs	**Units**	**Quantity**	**Description of sampling procedures**	**Origin**
Water consumption [a]	**Units**	**Quantity**		
Energy inputs [b]	**Units**	**Quantity**	**Description of sampling procedures**	**Origin**
Material outputs (including products)	**Units**	**Quantity**	**Description of sampling procedures**	**Destination**

NOTE The data in this data collection sheet refer to all unallocated inputs and outputs during the specified time period.

[a] For example, surface water, drinking water.

[b] For example, heavy fuel oil, medium fuel oil, light fuel oil, kerosene, gasoline, natural gas, propane, coal, biomass, grid electricity.

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Preparing

Data Collection Tables

Unit process identification:			Reporting location:
Emissions to air [a]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Emissions to water [b]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Emissions to land [c]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Other releases [d]	**Units**	**Quantity**	**Description of sampling procedures** (attach sheets if necessary)
Describe any unique calculations, data collection, sampling, or variation from description of unit process functions (attach additional sheets if necessary).			

CAN/CSA-ISO 14044:06

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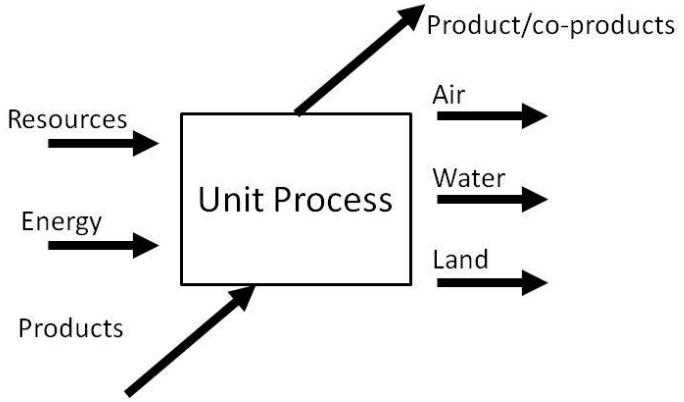
Preparing

Data Collection Tables

Note Input and Outputs from/to:

- Nature
- Technosphere (products)



Reference Flow – flow required to fulfil function (performance) expressed by functional unit

Intermediate Flow – flow occurring between unit processes

Elementary Flow – flow directly from or to environment (no further transformation)

Preparing

Data Collection Tables

Unit process inventory: Ethylene to HDPE resin

	Flow name	Category	Subcategory	Value	Unit	Notes/comments
Inputs from nature	Natural Gas	Resource/elementary	Ground			
	Bituminous coal	Resource/elementary	Ground			
	Hydropower	Resource/elementary	Water			
	Nuclear	Resource/elementary	Ground			
	Petroleum (crude oil)	Resource/elementary	Ground			
	Wood	Resource/elementary	Biosphere			
	Water	Resource/elementary	Water	1.5	liters	
Inputs from the technosphere	**Flow name**	**Category**	**Subcategory**	**Value**	**Unit**	**Notes/comments**
	Olefins (ethylene)	Product		0.99	kg	
	Water	Product				
	Electricity (grid)	Product		0.178	kWh	
	Natural Gas	Product		0.035	cubic meters	
	LPG	Product		0.000038	liters	
	Residual oil	Product		0.006	liters	
	Gasoline	Product				
	Diesel	Product				
Outputs to nature	**Flow name**	**Category**	**Subcategory**	**Value**	**Unit**	**Notes/comments**
	Carbon Dioxide - Fossil	Air/elementary	High population	0.1	kg	
	Methane	Air/elementary	High population	0.000014	kg	
	Nitrous Oxide	Air/elementary				
	Carbon Dioxide - Non-Fossil	Air/elementary				
	Particulates (unspecified)	Air/elementary	High population	0.000018	kg	
	Particulates (PM10)	Air/elementary	High population	0.000041	kg	
	Particulates (PM2.5)	Air/elementary	High population	0.000012	kg	
	Nitrogen Oxides	Air/elementary	High population	0.000029	kg	
	Sulfur Dioxide	Air/elementary				
	Sulfur Oxides	Air/elementary	High population	0.000000048	kg	
	VOC (unspecified)	Air/elementary				

Elementary flow type	Category	Subcategory
Inputs from nature	Resource	Biotic (from biosphere)
		In air
		In ground
		In water
Outputs to nature	Air	High population density
		Low population density
	Land	Unspecified
	Water	Unspecified

Method Overview

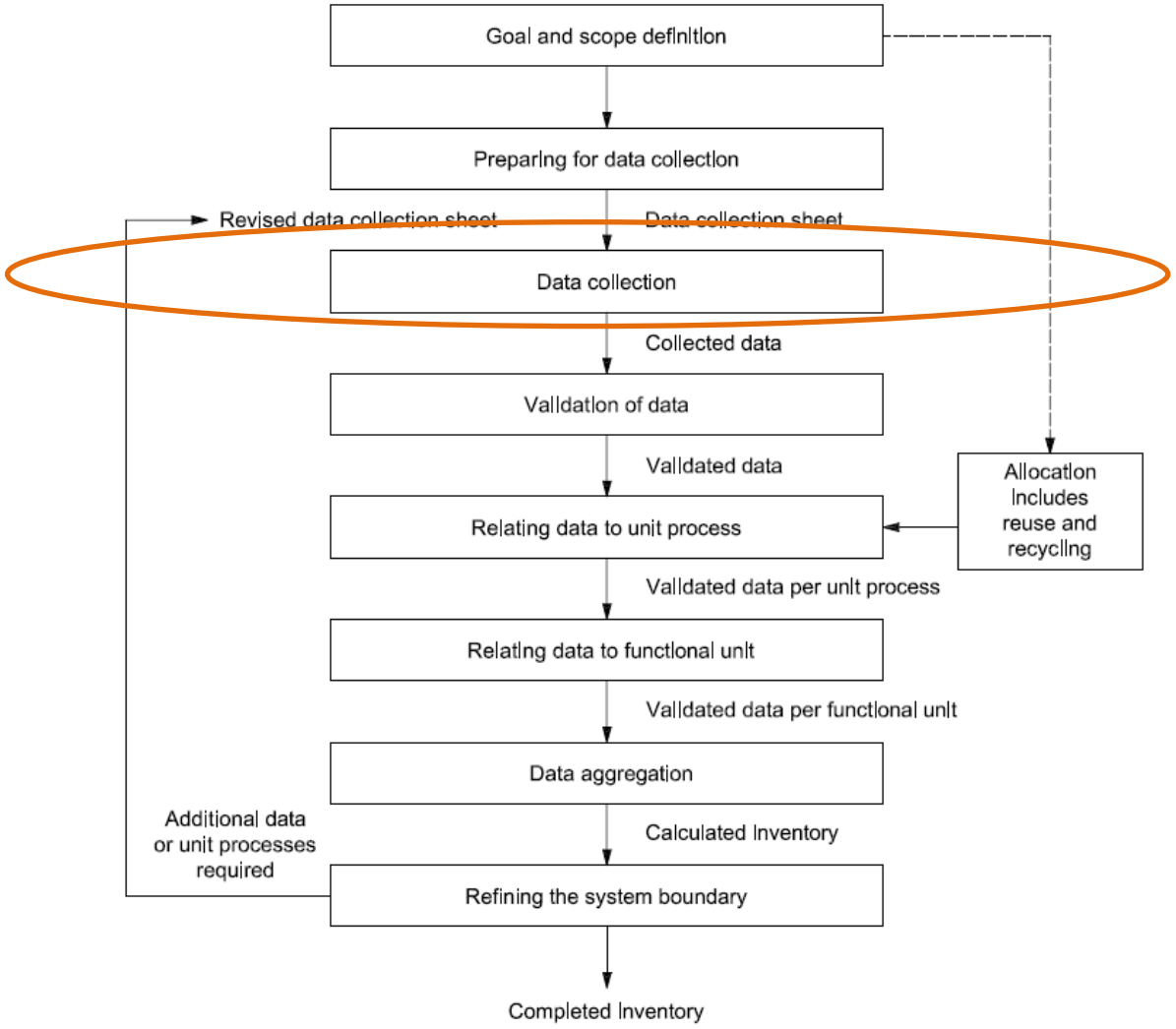


Figure 1 — Simplified procedures for inventory analysis

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Collecting

Surveying
Manufacturers

A CRADLE-TO-GATE LIFE CYCLE ASSESSMENT OF CLAY BRICK PRODUCTS

This questionnaire is designed specifically for "Clay Brick" production at various Canadian and US facilities (see the Process Flow Diagram, Page 2). The survey is broken into two parts: (Part I) – raw materials winning/extraction and transport to the plant and (Part II) - clay brick production.

Clay Brick Plant Address _____

Plant Code *(office use)* _____

Contact Person _____

Position/Title _____

Telephone _____

Email _____

Please complete the data collection sheets by either printing this form and writing in your responses or typing your responses directly into the spaces provided. We would appreciate questionnaire responses for the calendar year 2007.
Space is provided throughout the questionnaire for any additional comments, clarifications or observations you might care to add.
If you have questions regarding completion of this questionnaire, please contact Mr. Jamie Meil (613-729-9996 x 224, Email: jamie.meil@athenasmi.org). Completed questionnaires can be returned to Mr. Meil by email or Fax (613-729-9997)

Thank you for your cooperation!

DRAFT

Collecting

Research Databases

- LCI Databases
  - Athena LCI Database
    - http://www.athenasmi.org/our-software-data/lca-databases/
  - US LCI
    - https://www.lcacommons.gov/nrel/search
  - ELCD
    - http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm
  - EcoInvent
    - http://www.ecoinvent.org/database
  - GaBi
    - http://www.gabi-software.com/databases

Collecting

Research
LCA Community
Literature

Notable Journals
International Journal of Life Cycle Assessment
Journal of Industrial Ecology
Journal of Cleaner Production

A few LCA Communities
lcinitiative.unep.fr (UN Life Cycle Initiative)
lcacenter.org (American Centre for Life Cycle Assessment)
life-cycle.org (LCA Links)
ciraig.org (Interuniversity Research Centre for the Life Cycle of Products, Processes and Services)
lct.jrc.ec.europa.eu (European Commission Joint Research Centre – Institute for Environment and Sustainability)
calcasproject.net (Coordination Action for Innovation for LCA for Sustainability)
cstb.fr (French Scientific and Technical Centre of the Building Industry)

And many others..

http://lcaalliance.com/lca-links/

Method Overview

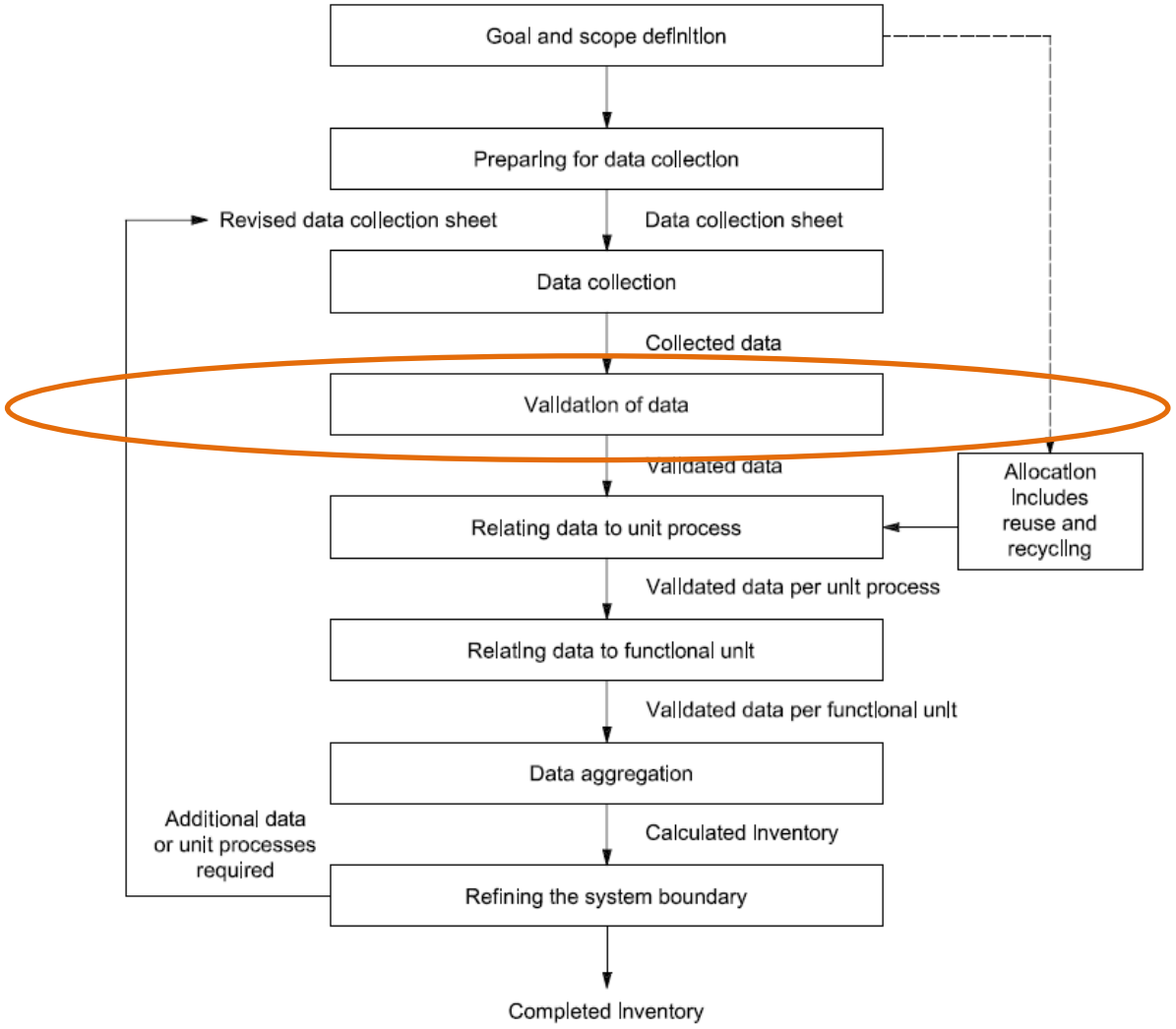

Figure 1 — Simplified procedures for inventory analysis

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Validating

Validation of Data

- Check
  - Data quality requirements established in G&S
  - Mass and Energy balance
  - Compare with other sources

- ❑ **Time related coverage** – is the data the right vintage and was it collected over an appropriate time span?
- ❑ **Geographical coverage** – is the data collected from a comparable the geographical area?
- ❑ **Technology coverage** – does it include the right technology(ies)?
- ❑ **Precision** – is there a high variance in the dataset?
- ❑ **Completeness** – is it well documented and does it encompass the entirety of the required data?
- ❑ **Representativeness** – does the data simulate the appropriate circumstances?
- ❑ **Consistency** – were the methods used to collect the data consistent with the relevant standards?
- ❑ **Reproducibility** – is there enough documentation to enable a third party to understand the methods and data in order to repeat the study
- ❑ **Uncertainty of the information** – is there enough information on the data to enable a qualitative and/or quantitative uncertainty analysis?

Presentation Outline

1. What is Inventory Analysis?
2. Life Cycle Inventory procedures.
3. **Exercise developing and managing inventory data.**

Method Overview

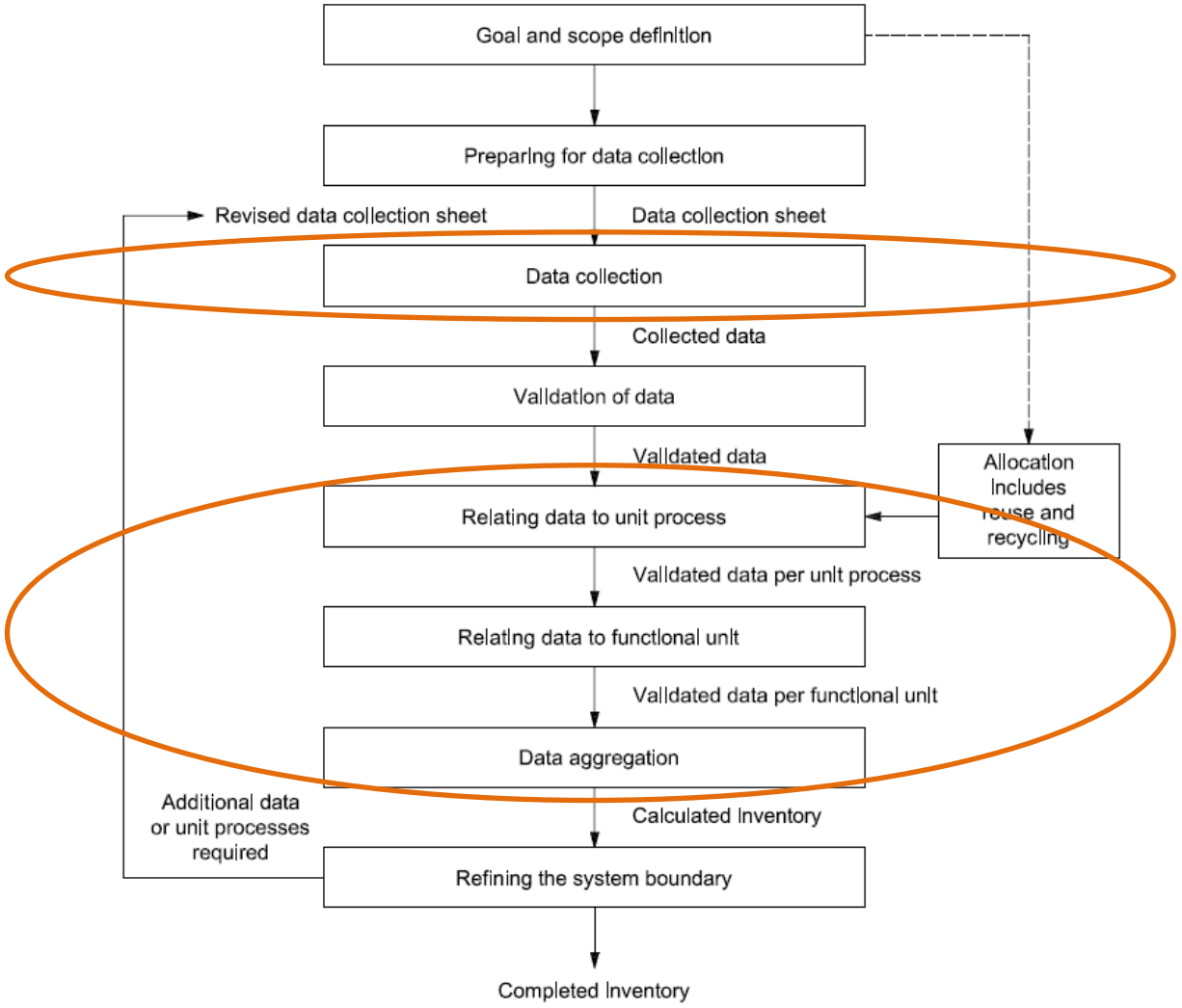

Figure 1 — Simplified procedures for inventory analysis

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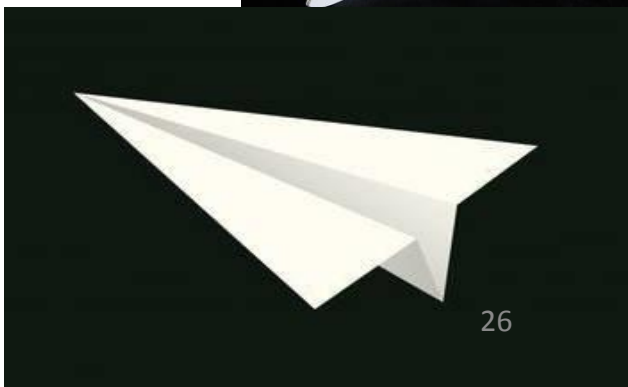
Hands on
Inventory Analysis Exercise

Spheres and Planes



Exercise Materials:

1. Exercise Directions
2. Data Collection Sheets
3. Data Processing Sheets

October 1st, 2014.

Inventory Analysis Exercise Directions

Your air travel company offers two air travel services by airplane and by sphere to destinations all over the globe. Your customers want to make more sustainable travel choices to minimize their time impact. Keen to help them, your company decides to carry out a cradle-to-grave life cycle inventory (LCI) study to determine the time needed to provide each travel service option. Carry out the following directions with your air travel company team members.

1. Come up with a name for your air travel company and define Goal parameters for your company's LCI study.
   a. Intended application? _____
   b. Reason for carrying out the study? _____
   c. Intended audience? _____
   d. Intended for comparative assertions? _____
2. Read the directions for the Unit Processes on the *data collection sheet* provided.
3. Create a process flow diagram that illustrates the structure and relationship between the Airplane and Sphere product systems. Include unit processes as boxes, products/co-product flows with arrows to indicate the direction of their product flows, and the system boundary as a dashed line.
   a. What is an appropriate functional unit of the product system supported by your air travel company's services? _____
4. Assign one group member as the Timer and assign the rest of the life cycle modules to the other group members.
5. Starting from Raw Material Acquisition Stage – the Timer begins timing their group members in sequence as they carry out the respective Unit Process directions, from Raw Material Acquisition to End-of-Life Stage. The Timer records the times for the respective Unit Processes in the *data collection sheet* provided. NOTE: This also includes recording distance travelled in the Use stage.
6. Once all stages are complete. Identify where inventory flows share Unit Processes, and apply a mass allocation procedure to the shared inventory flows in the Sphere and Airplane Product Systems. Assume your extracted piece of paper weighs 1kg, and make note of the allocation factors used.
7. Relate inventory flows using your functional unit and record your final allocated and functional unit related inventory analysis results in the final columns of your data processing sheet.
8. Aggregated (ie. sum) the inventory results for each life cycle module and for your Airplane and Sphere product systems.